AD-A068 460 HARRY DIAMOND LABS ADELPHI MD F/G 18/9
NEUTRON-FLUX MAPPING OF AFRRI EXPOSURE ROOMS.(U)
NOV 78 C R HEIMBACH
UNCLASSIFIED HDL-TM-78-19 NL

1 OF 1
ADA
068460

END
DATE
FILMED
6-79
DDC

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: 14 HDL-TM-78-19

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle): 6 Neutron-Flux Mapping of AFRRI Exposure Rooms

5. TYPE OF REPORT & PERIOD COVERED: 9 Technical Memorandum

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s): 10 Craig R. Heimbach

8. CONTRACT OR GRANT NUMBER(s): 12 φ2

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
Harry Diamond Laboratories
2800 Powder Mill Road
Adelphi, MD 20783

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 16
DA: 1L162120AH2502
Prog. Ele: 6.21.20

11. CONTROLLING OFFICE NAME AND ADDRESS:
U.S. Army Materiel Development and Readiness Command
Alexandria, VA 22333

12. REPORT DATE: 11 Nov[redacted]78

13. NUMBER OF PAGES: 11

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): 12 11p.

15. SECURITY CLASS. (of this report): UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

HDL project: X75826
DRCMS Code: 612120.H250011

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Neutron flux
Fission chambers
Threshold foils

greater than

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The neutron flux in the Armed Forces Radiobiology Research Institute (AFRRI) reactor exposure rooms has been mapped by means of a National Bureau of Standards fission chamber. The chamber contained loadings of both ^{239}Pu and ^{237}Np, so that the reported fluxes are for neutrons >10 and >600 keV in energy. Most of the measurements were taken along the centerline height of the reactor core and perpendicular to the wall facing the reactor pool. A few

DD FORM 1473, 1 JAN 73 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

163 050

sat

measurements were also made at other heights and angles in order to establish the flux distribution in a wide volume in each exposure room.

This mapping will aid neutron damage experiments at AFRRI by allowing a more precise determination of the neutron environment.

CONTENTS

FIGURES

TABLES

1. INTRODUCTION

A series of measurements was taken in the exposure rooms of the Armed Forces Radiobiology Research Institute (AFRRI) to better characterize the fast-neutron environment. These measurements were taken in anticipation of Harry Diamond Laboratories (HDL) personnel using these exposure rooms for radiation-damage experiments.

The AFRRI reactor is a TRIGA Mark F reactor, and can be operated either at a steady-state power level or in a pulsed mode. All measurements for this report were taken in the steady-state mode. The AFRRI reactor has two exposure rooms which differ in size (see fig. 1). The larger exposure room (ER1) has a movable lead shield which may be positioned in front of the reactor.

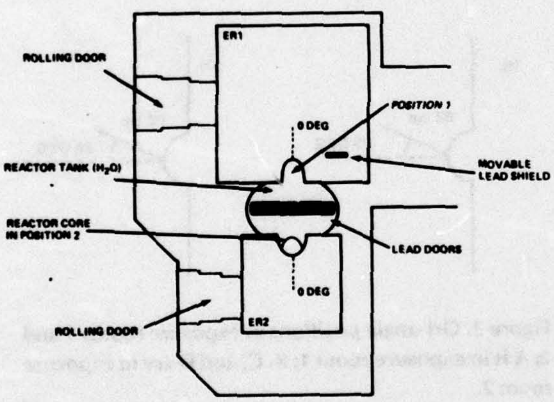

Figure 1. Design of AFRRI exposure rooms.

Fast neutrons were detected by means of a boron-covered National Bureau of Standards (NBS) fission chamber, as pictured in figure 2. The chamber consists of two back-to-back ionization chambers; one chamber had a deposit of 0.000472 g of plutonium-239 and the other had a deposit of 0.000604 g of neptunium-237. When neutrons enter the chamber, they cause the neptunium and plutonium to fission. The fission fragments are detected, and give rise to an electronic pulse. The number of pulses per second is equal, after some

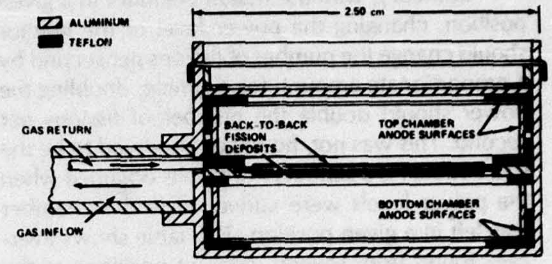

Figure 2. NBS fission chambers.

corrections are applied,[1] to the number of fissions per second. This is related to the neutron flux by

$$\phi = \frac{A}{N_A M \ <\sigma>} \ f \qquad (1)$$

where ϕ is the total neutron flux, A is the atomic weight of the fissionable isotope, N_A is Avogadro's number, M is the mass of the fissionable isotope, $<\sigma>$ is the spectrum-averaged cross section, and f is the number of fissions per second. Since there are actually two chambers, both the flux as determined by plutonium and that determined by neptunium may be found simultaneously. The chambers were covered with 2.21 g/cm^2 of boron-10 to eliminate any response to neutrons below 10 keV.

2. POWER LEVEL MONITOR

Operating the reactor in a pulsed mode would saturate the chamber, so all data were taken with the reactor operating in the steady-state mode. In the taking of data, the reactor was run at various power levels. Close to the reactor, the chambers were run at lower levels to minimize dead-time corrections. Farther back into the room, the reactor was run at higher power levels to obtain sufficient statistics in a reasonably short time. At many positions, the reactor was run at several power levels.

[1] J. A. Grundl, D. M. Gilliam, N. D. Dudey, and R. J. Popek, *Measurement of Absolute Fission Rates*, Nucl. Tech. *25* (1975), 237–257.

In theory, with the fission chamber in a given position, changing the power level of the reactor should change the number of fissions per second by a proportionate amount; for example, doubling the power should double the number of fissions per second. This was not, however, observed to be the case. Table I is a summary of results obtained when the power levels were varied while the chamber was left in a given position. This table shows averages found from several different positions of the chamber in both exposure rooms. All the data in this table are normalized under the assumption that the 1000 W indicated by reactor instrumentation was correct.

TABLE I. POWER INDICATED BY FISSION CHAMBERS AS A FUNCTION OF REACTOR POWER

Note: 1000 W is calibration point for fission chamber.

Reactor power (W)	Indicated power (W)	Percent deviation
15.	15.1 ± 0.05	+0.6
50.	50.9 ± 0.08	+1.8
100.	104.7 ± 0.6	+4.7
500.	488.0 ± 3.	−2.4
1000.	1000.	0.0
2000.	1980. ± 13	−1.0
5000.	4750. ± 40	−5.0

Table I shows that the fission-chamber and the reactor power-level monitors differ by as much as 5 percent in the range from 15 to 5000 W. One should be especially cautious in trying to extrapolate these results beyond 5000 W.

3. FLUX RESULTS

The results of the experiment are listed in tables II and III. Measurements were taken from various places in the exposure rooms, specified in the "Location" columns. The dotted lines in figure 1, labelled "0 deg," are parallel to the left and right walls of the exposure rooms, and originate at the height of the center of the reactor core (120 cm from the floor in exposure room 2—ER2—and 92 cm in ER1). Distances are measured from the tank wall surface; off-angle positions are diagrammed in figure 3. The only positions not at the height of the reactor core are labelled "up." Measurements were also taken in ER2 with the reactor moved back into the water an extra 6 in. (15.24 cm) and an extra 12 in. (30.48 cm). Distance measurements in the exposure rooms are accurate to ±0.5 cm.

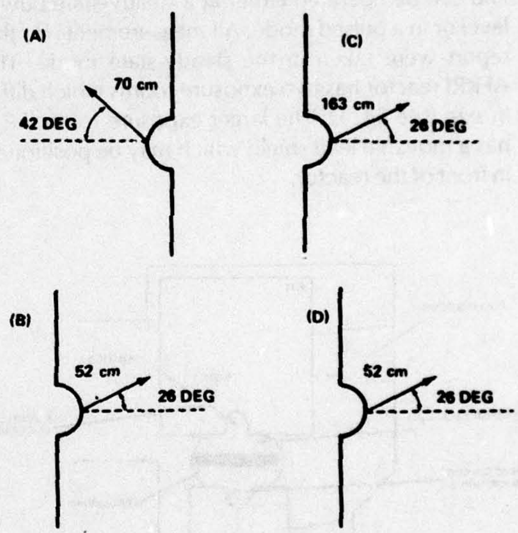

Figure 3. Off-angle positions in exposure rooms 1 and 2; A is in exposure room 1; B, C, and D are in exposure room 2.

The results are given both in terms of fissions per second and flux (n/cm²-s) in order to separate out the effect of the uncertainty in the boron-covered spectrum-averaged cross section, which is the largest source of error. This will affect only the normalization of the flux. The values used to convert from fissions per second to flux are $K = 4.43 \times 10^{6} \pm 5$ percent for neptunium-237 (giving >600 keV flux) and $5.64 \times 10^{5} \pm 7$ percent for plutonium-239 (giving >10 keV flux), using the equation

$$\phi = Kf\,. \tag{2}$$

TABLE II. FISSION RATES AND FLUX IN EXPOSURE ROOM 1

Location: Angle from centerline (deg)	Location: Distance from core (cm)	Location: Height from floor	Neptunium-237 fissions/s at 1000 W	Plutonium-239 fissions/s at 1000 W	10-keV flux at 1000 W (n/cm^2-s)	600-keV flux at 1000 W (n/cm^2-s)	Ratio $\geq$10 keV / >600 keV
0	6	HC[a]	983 ± 15	1323.9 ± 20	7.47×10^8	4.35×10^8	1.72
0	11.5	HC	710.8 ± 40	963 ± 20	5.43×10^8	3.15×10^8	1.72
0	28	HC	335.2 ± 6	498 ± 65	2.81×10^8	1.48×10^8	1.90
0	72	HC	99.2 ± 3	150 ± 6	8.46×10^7	4.39×10^7	1.91
0	160	HC	28.3 ± 0.7	73.5 ± 1.6	4.14×10^7	1.25×10^7	3.31
0	247	HC	14.1 ± 0.5	45.7 ± 2	2.58×10^7	6.25×10^6	4.13
42 (A)[b]	70	HC	110.4 ± 2	173.4 ± 4	9.78×10^7	4.89×10^7	2.0
0	78	41 cm up	29.4 ± 1.0	68.0 ± 1.0	3.83×10^7	1.30×10^7	2.95
0	79	70 cm up	54.2 ± 1.5	97.1 ± 3	5.48×10^7	2.40×10^7	2.28
(with lead shield)							
0	72	HC	74.3 ± 1.5	123.2 ± 4	6.95×10^7	3.29×10^7	2.11
0	160	HC	19.9 ± 0.5	53.7 ± 1.2	3.03×10^6	8.81×10^6	3.44

[a]HC = height at core (92 cm in ER1)
[b]See figure 3 for diagrams of angle positions

TABLE III. FISSION RATES AND FLUX IN EXPOSURE ROOM 2

Location: Angle from centerline (deg)	Location: Distance from core (cm)	Location: Height from floor	Neptunium-237 fissions/s at 1000 W	Plutonium-239 fissions/s at 1000 W	10-keV flux at 1000 W (n/cm^2-s)	600-keV flux at 1000 W (n/cm^2-s)	Ratio $\geq$10 keV / >600 ke
0	8	HC[a]	851.8 ± 30	1432.2 ± 30	8.08×10^8	3.77×10^8	2.14
0	11.5	HC	642.3 ± 9	1116 ± 18	6.29×10^8	2.84×10^8	2.21
0	30	HC	301.0 ± 5	519.5 ± 8	2.93×10^8	1.33×10^8	2.20
0	71.5	HC	98.7 ± 2.5	217.6 ± 5	1.23×10^8	4.37×10^7	2.81
0	158	HC	29.0 ± 1.8	104.9 ± 4	5.92×10^7	1.28×10^7	4.62
26 (B)[b]	52	HC	—	282.0 ± 6	1.59×10^8	—	—
26 (C)[b]	163	HC	—	93.0 ± 2.5	5.24×10^7	—	—
26 (D)[b]	52	61 cm up	—	282.0 ± 6	1.59×10^8	—	—
0	49	61 cm up	—	239.4 ± 6	1.35×10^8	—	—
(with H_2O)							
0	30	HC	24.23 ± 2.2	44.9 ± 1.5	2.53×10^7	1.07×10^7	2.36
0	30	HC	3.48 ± 0.15	9.1 ± 0.3	5.13×10^6	1.54×10^6	3.33

[a]HC = height at core (120 cm in ER2)
[b]See figure 3 for diagrams of angle positions

Some of the results of the neptunium flux for ER2 are missing because one of the preamplifiers necessary for taking data failed during the course of the experiment.

The 0-deg data for the two exposure rooms are plotted in figures 4 and 5.

The two exposure rooms have about the same flux out to a distance of 40 cm from the tank wall. Beyond that distance, ER2 has more >10-keV neutrons and about the same number of >600-keV neutrons, indicating a softening of the spectrum as one approaches the back wall of the exposure room.

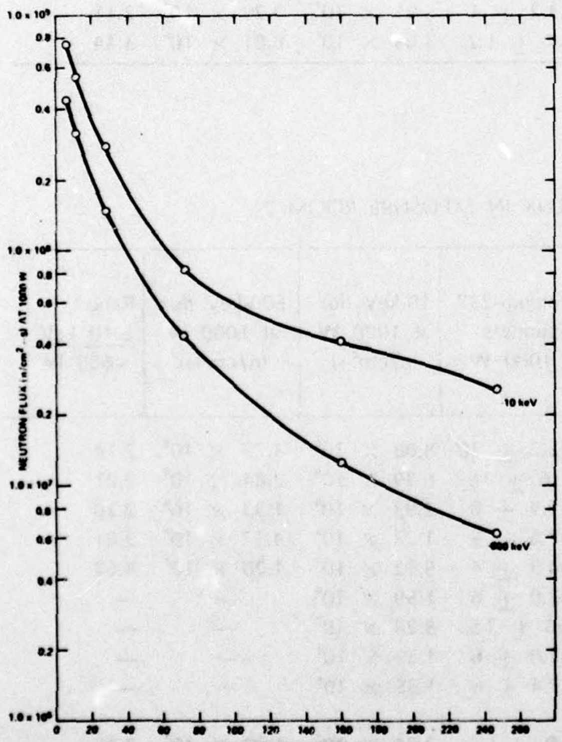

Figure 4. >10 and >600 keV neutron flux at 1000 W in exposure room 1.

The effect of the lead shield in ER1 is to cause about a 25-percent decrease in total fast flux and a slight softening of the spectrum. Moving the reactor back into the water significantly reduces neutron flux and greatly softens the neutron spectrum.

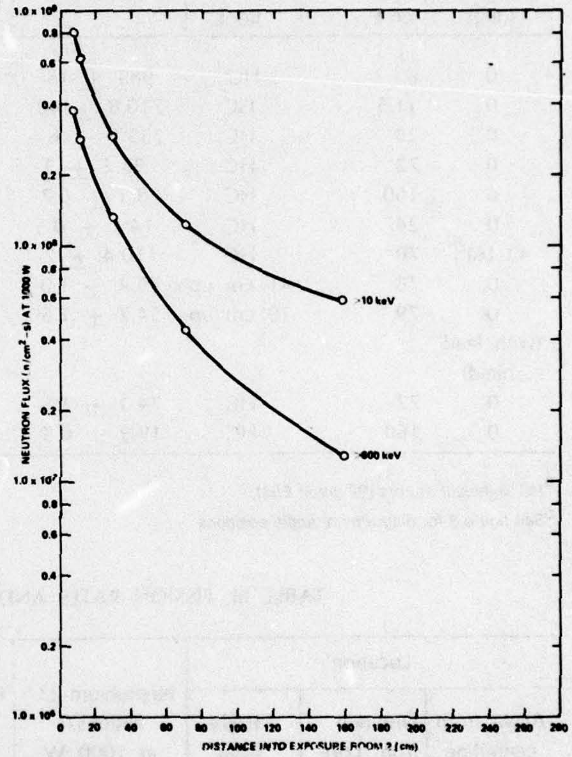

Figure 5. >10 and >600 keV neutron flux at 1000 W in exposure room 2.

4. CONCLUSIONS

The >10 and >600 keV neutron fluxes have been measured in the two AFRRI exposure rooms with emphasis in the direction along the 0-deg line at the height of the center of the reactor core. The results are reported in terms of 1000 W of reactor power. The positioning errors are ±0.5 cm, the relative point-to-point fission rate errors are about 3 percent, and the absolute normalization uncertainty is 7 and 5 percent for >10 and >600 keV flux, respectively.

DISTRIBUTION

ADMINISTRATOR
DEFENSE DOCUMENTATION CENTER
ATTN DDC-TCA (12 COPIES)
CAMERON STATION, BUILDING 5
ALEXANDRIA, VA 22314

COMMANDER
US ARMY RSCH & STD GP (EUR)
ATTN LTC JAMES M. KENNEDY, JR.
CHIEF, PHYSICS & MATH BRANCH
FPO NEW YORK 09510

COMMANDER
US ARMY MATERIEL DEVELOPMENT & READINESS COMMAND
ATTN DRXAM-TL, HQ TECH LIBRARY
5001 EISENHOWER AVENUE
ALEXANDRIA, VA 22333

COMMANDER
US ARMY ARMAMENT MATERIEL READINESS COMMAND
ATTN ATTN DRSAR-LEP-L, TECH LIBRARY
ROCK ISLAND, IL 61299

COMMANDER
US ARMY MISSILE & MUNITIONS CENTER & SCHOOL
ATTN ATSK-CTD-F
REDSTONE ARSENAL, AL 35809

DIRECTOR
US ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY
ATTN DRXSY-MP
ATTN TECHNICAL LIBRARY
ABERDEEN PROVING GROUND, MD 21005

DIRECTOR
US ARMY BALLISTIC RESEARCH LABORATORY
ATTN DRDAR-TSB-S (STINFO)
ABERDEEN PROVING GROUND, MD 21005

DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
WASHINGTON, DC 20234
ATTN LIBRARY

DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
CENTER FOR RADIATION RESEARCH
WASHINGTON, DC 20234

US ENERGY RESEARCH & DEVELOPMENT ADMINISTRATION
WASHINGTON, DC 20545
ATTN ASST ADMIN FOR NUCLEAR ENERGY

DIRECTOR
ARMED FORCES RADIOBIOLOGY RESEARCH INSTITUTE
DEFENSE NUCLEAR AGENCY
NATIONAL NAVAL MEDICAL CENTER
BETHESDA, MD 20014 (20 COPIES)

DIRECTOR
NATIONAL SECURITY AGENCY
FORT GEORGE G. MEADE, MD 20755
ATTN O. D. VAN GUNTEN, R-425
ATTN TECHNICAL LIBRARY

DIRECTOR
DEFENSE NUCLEAR AGENCY
WASHINGTON, DC 20305
ATTN E. CONRAD, ASST DEP DIR, SCIENTIFIC TECHNOLOGY
ATTN RAEV, ELECTRONIC VULNERABILITY
ATTN TITL, LIBRARY

COMMANDER
US ARMY ARMAMENT RESEARCH & DEVELOPMENT COMMAND
DOVER, NJ 07801
ATTN DRDAR-LCN, NUCLEAR APPLICATIONS DIV

COMMANDER
BALLISTIC MISSILE DEFENSE ADVANCED TECHNOLOGY CENTER
PO BOX 1500
HUNTSVILLE, AL 35807
ATTN TECH LIB

DISTRIBUTION (Cont'd)

COMMANDER/DIRECTOR
COMBAT SURVEILLANCE & TARGET
ACQUISITION LABORATORY
FORT MONMOUTH, NJ 07703

COMMANDER
US ARMY COMMUNICATIONS &
ELECTRONICS MATERIEL READINESS
COMMAND
FORT MONMOUTH, NJ 07703
ATTN SELEM-ES, DIR FOR ELECT
SYSTEM MAINTENANCE

COMMANDER
US ARMY MATERIALS & MECHANICS
RESEARCH CENTER
WATERTOWN, MA 02172
ATTN DRXMR-PL, TECHNICAL LIBRARY

COMMANDER
US ARMY MATERIEL READINESS COMMAND
ROCK ISLAND ARSENAL
ROCK ISLAND, IL 61299
ATTN DRSAR-ASN, NUCLEAR, CHEMICAL
& WARHEADS DIV
ATTN DRSAR-MMN, NUCLEAR & CHEM DIV

DIRECTOR
NIGHT VISION & ELECTRO-OPTICS
LABORATORY
FORT BELVOIR, VA 22060
ATTN TECHNICAL LIBRARY

COMMANDER
US ARMY NUCLEAR & CHEMICAL AGENCY
7500 BACKLICK RD
BUILDING 2073
SPRINGFIELD, VA 22150
ATTN ATCN-W, WEAPONS EFFECTS DIV

COMMANDER
US ARMY NUCLEAR & CHEMICAL
SURETY GRP
FT. BELVOIR, VA 22060
ATTN LIBRARY

COMMANDER
US ARMY ABERDEEN PROVING GROUND
ABERDEEN PROVING GROUND, MD 21005
ATTN STEAP-TL, TECH LIB

DIRECTOR
NAVAL RESEARCH LABORATOTY
WASHINGTON, DC 20375
ATTN CODE 2620, LIBRARY
ATTN CODE 6600, RADIATION
TECH DIV

COMMANDER
NAVAL SURFACE WEAPONS CENTER
DAHLGREN, VA 22448
ATTN DX-21, LIBRARY DIV

COMMANDER
NAVAL SURFACE WEAPONS CENTER
WHITE OAK, MD 20910
ATTN WA-50, NUCLEAR WEAPONS
EFFECTS DIV
ATTN WX-40, TECHNICAL LIB

COMMANDING OFFICER
NAVAL WEAPONS EVALUATION
FACILITY
KIRTLAND AIR FORCE BASE
ALBUQUERQUE, NM 87117
ATTN TECH LIBRARY

COMMANDING OFFICER
NAVAL WEAPONS SUPPORT CENTER
CRANE, IN 47522
ATTN TECHNICAL LIBRARY

COMMANDER
HQ AERONAUTICAL SYSTEMS DIV (AFSC)
WRIGHT-PATTERSON AFB, OH 45433

DIRECTOR
AF AVIONICS LABORATORY
WRIGHT-PATTERSON AFB, OH 45433
ATTN LDF (TSR), STINFO BR

DISTRIBUTION (Cont'd)

COMMANDER
HQ AF TEST & EVALUATION CENTER
KIRTLAND AFB, NM 87115
ATTN TEK, ELECTRONICS DIV

COMMANDER
AF WEAPONS LAB, AFSC
KIRTLAND AFB, NM 87117
ATTN EL, ELECTRONICS DIV

US ARMY ELECTRONICS RESEARCH
& DEVELOPMENT COMMAND
ATTN WISEMAN, ROBERT S., DR., DRDEL-CT
ATTN PAO

HARRY DIAMOND LABORATORIES
ATTN 00100, COMMANDER/TECHNICAL DIR/TSO
ATTN CHIEF, 00210
ATTN CHIEF, DIV 10000
ATTN CHIEF, DIV 20000
ATTN CHIEF, DIV 30000
ATTN CHIEF, DIV 40000
ATTN CHIEF, LAB 11000
ATTN CHIEF, LAB 13000
ATTN CHIEF, LAB 15000
ATTN CHIEF, LAB 22000
ATTN CHIEF, LAB 21000
ATTN CHIEF, LAB 34000
ATTN CHIEF, LAB 36000
ATTN CHIEF, LAB 47000
ATTN CHIEF, LAB 48000
ATTN RECORD COPY, 94100
ATTN HDL LIBRARY, 41000 (5 COPIES)
ATTN HDL LIBRARY, 41000 (WOODBRIDGE)
ATTN CHAIRMAN, EDITORIAL COMMITTEE
ATTN TECHNICAL REPORTS BRANCH, 41300
ATTN LEGAL OFFICE, 97000
ATTN LANHAM, C., 00210
ATTN WILLIS, B., 47400
ATTN CHIEF, BR 22800 (5 COPIES)
ATTN CHIEF, BR 22900
ATTN CHIEF, BR 22300
ATTN CHIEF, BR 22100
ATTN HEIMBACH, C. R., 22900 (10 COPIES)